National Bureau of Standards

TECHNICAL NEWS BULLETIN

DECEMBER 1946 No. 356

Cycle-Testing Laboratory for Aircraft Batteries

A new laboratory for battery research has been constructed at the Bureau with the cooperation of the Bureau of Aeronautics, Navy Department. Equipped with completely automatic controls for cycling batteries, this laboratory offers a unique method of testing batteries under conditions simulating those encountered in practice—conditions that are particularly important for aircraft batteries. Such problems as maximum electrical capacity per unit weight, charging technics, and the effect of these technics on battery life will be investigated.

In present-day aircraft, the storage battery plays an important rôle in the operation of electrical equipment such as radio, radar, and lighting. It also serves as a source of stand-by power in the operation of the gun turrets, bomb bays, and retractable landing gear. Since every pound added to a plane increases the take-off distance, weight is also of major concern. Hence, obtaining maximum capacity per unit weight of the battery with reasonable life expectancy is the principal aim of the experimental tests conducted at the Bureau.

The equipment in the laboratory provides for discharging the batteries through constant resistance and recharging them either at constant potential or at constant current, as desired. The cycling may be performed automatically for batteries under conditions of room temperature, extreme heat, subzero temperatures, and "flight" vibration.

Six similar cycling units have been installed, each operated independently by a master electric clock. Each unit consists essentially of a control cabinet, two motor-generator sets, and the necessary resistors. From one to six 24-volt batteries may be cycled on each unit, the only requirement being that the batteries on a given unit have approximately equal rated capacities. When charging at constant potential, the batteries are connected in parallel; when charging at constant current or when discharging, they are connected in series. These connections are made automatically.

An important feature of the laboratory is the control cabinet, one of which is provided for each cycling unit. Each cabinet contains a program machine for automatic cycling, sequence relays, contactors (aircraft type), and a copper oxide rectifier which supplies 24-volt current for operating the switching devices. Three single phase transformers located in alternate control cabinets supply 115-volt alternating current for the rectifiers. The transformers are supplied by the respective phases of the alternating current supply for the motor-generator sets.

Included on the control cabinets are follower clocks mounted on the back of the program machines, the various voltmeters, ammeters, cycle-counters, and ampere-hour meters, and the trunk line terminals (fig. 1). The trunk lines provide for transferring one or more batteries from the normal test position to a refrigerator, an electric furnace, or a vibrating machine to approximate conditions encountered in practice. The program machine of each unit is mounted on the back of a hinged panel which swings outward to make it accessible. The sequence relays, contactors and shunts are located inside the cabinets with the sequence relays in two horizontal rows near the top, the contactors in the middle, and the shunts in two rows near the bottom of the wall (fig. 3).

The motor-generators have squirrel-cage induction type motors and compound-wound generators equipped with voltage regulators and reverse current relays (fig. 2). The machines are two-bearing units with both rotors and fan mounted on the same shaft. The motors are rated at 11 horse-power and the generators at 30 volts, 250 amperes maximum. Two machines operate in parallel for each cycling unit when charging at constant potential. Each motor-generator set is provided with an independent line starter so that either machine may be disconnected when the peak load is passed. When charging at constant current the batteries are switched to the 115/230-volt direct-current power supply.

When discharging the batteries, natural circulation by flue action is depended upon for removing the heat from the resistor housing. The resistor units are made of nichrome ribbon for high rates of discharge, while helical coils of nichrome wire provide for intermediate and low rates of discharge and for charging at constant current. The resistor units are mounted on sheet metal panels and tapped for one to six batteries. The desired current values can be obtained approximately from combinations of the resistor units in series and parallel. Fine adjustments of one ampere or less may be obtained

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from rheostats mounted in the control cabinets. The maximum safe discharge rate for each cycling unit is about 250 amperes.

The cycle-testing control begins with the master clock which provides electrical impulses at intervals of 1 minute for advancing all of the program machines. A 24-volt battery maintained on trickle charge provides energy for winding the clock and for actuating the program machines.

Each program machine carries three endless tapes that pass under contact fingers and control six program circuits. The tapes are printed with the time of day and night and make 1 revolution in 24 hours. A program is set up by punching holes near the edges of the tapes in accordance with the time schedule for the required operations.

The six control circuits in each program machine control the following operations, respectively:

Circuit 1. (a) Starts motor-generator sets and connects batteries in parallel on constant potential charge. (b) Stops motor-generator sets and disconnects batteries.

Circuit 2. (a) Connects batteries in series on constant current charge. (b) Disconnects batteries.

Circuit 3. (a) Connects batteries in series on high-rate discharge. (b) Disconnects batteries.

Circuit 4. (a) Connects batteries in series on intermediate rate or low rate of discharge. (b) Disconnects batteries.

Circuit 5. (a) Short-circuits a portion of the charging resistor for constant current charging at normal rate. (b) Opens short-circuit on resistor for finishing rate.

Circuit 6. (a) Operates cycle counter. (b) Disconnects one motor-generator set after peak load is passed when charging at constant potential.

The control circuits in any program machine can be used independently or concurrently in any order depending upon the program which has been set up. Toggle switches in the machines provide for switching to manual operation when desired, and skip pins which lift the contact fingers provide for omitting the program for specified intervals of time. Interlocking relays prevent the connection of batteries in series and parallel at the same time in the event of an error in manual switching or a failure of a sequence relay. Pilot lights on the control panel indicate when batteries are being charged at constant current. A "no voltage" disconnect with manual reset prevents overloads which might be caused by the simultaneous starting of the motor-generator sets after an interruption in the alternating current power.

Extensive experimental tests are now under way in the cycle-testing laboratory. Data from these tests will give an accurate comparison between the two methods—the constant potential and constant current—of charging batteries and their effect on the life of batteries.

The general plan of the laboratory was developed by C. L. Snyder of the Bureau's Electrochemistry Section, with the cooperation of Lt. Kenneth Dawkins of the Bureau of Aeronautics. Engineers of the Standard Electric Time Co. worked out the details for the automatic controls and constructed the control cabinets. The resistor units were designed and constructed by members of the Bureau staff, who also designed the layout for the laboratory and installed the equipment.

TECHNICAL NEWS BULLETIN

U. S. Department of Commerce
W. Averell Harriman, *Secretary*
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E. U. Condon, *Director*

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Vacuum-Tube Acceleration Pick-Up

A new electronic tube, in appearance much like an ordinary radio tube, but capable of measuring accurately the rapidly changing accelerations to which various parts of an airplane are subjected in flight, has been developed in the Bureau's Engineering Mechanics Laboratory, under the direction of Dr. Walter Ramberg. The new tube, known as the vacuum-tube acceleration pickup, (fig. 4), is also proving useful in such applications as measurement of accelerations in portions of the body of "dummy" pilots and living subjects when subjected to critical acceleration during crash landings or seat-ejections from jet-propelled airplanes.

The vacuum-tube acceleration pickup takes advantage of the effect of acceleration on the relative position of the electrodes in the tube. This is in contrast to the design of conventional tubes where this effect is suppressed as much as possible because it leads to electrical noise or microphonics. The tube contains a fixed, indirectly heated cathode with two plates, one on either side. The plates are elastically mounted to deflect in response to acceleration normal to the plane of the

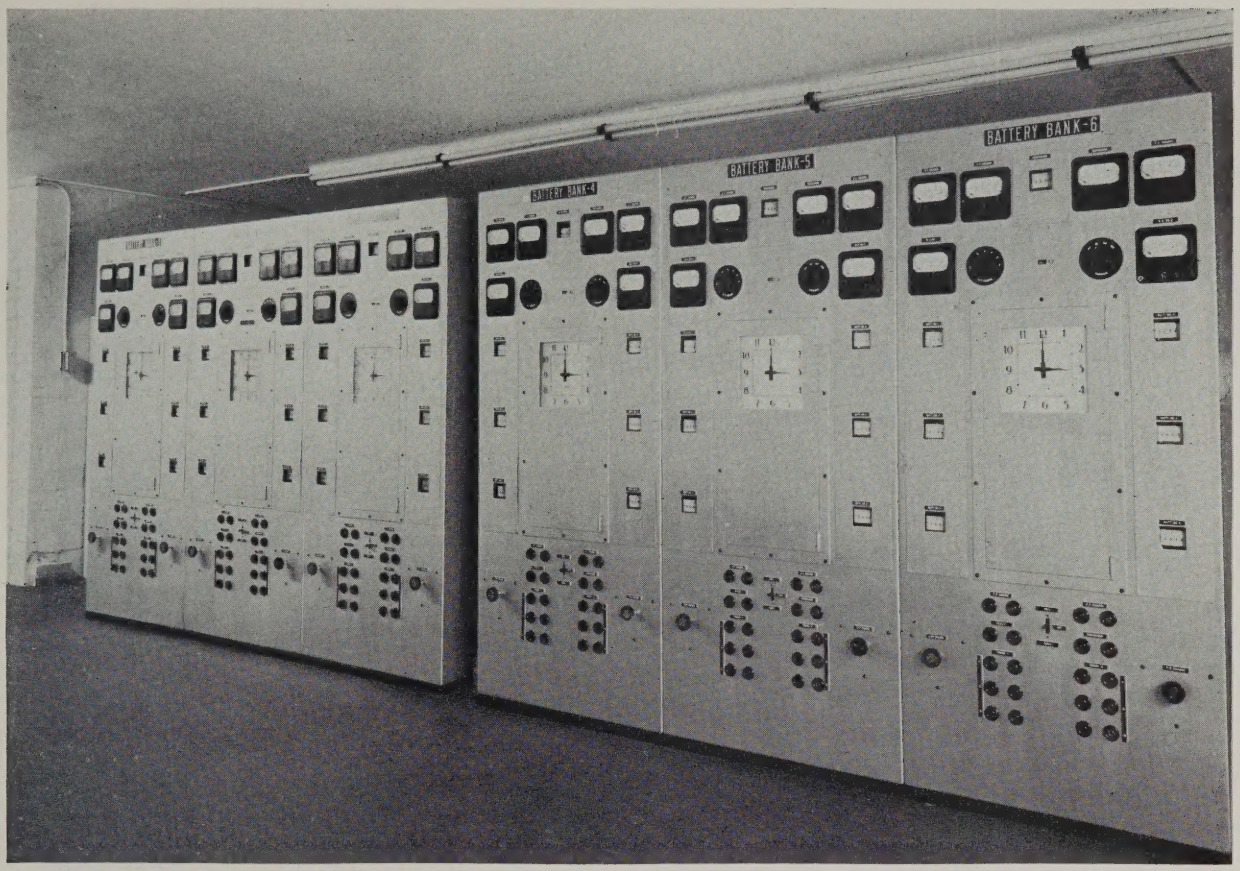

FIGURE 1.—*Control cabinets (front view) for cycling units in the Cycle-testing Laboratory for aircraft batteries*

In the center of each cabinet is located a hinged panel, on the front of which is mounted the follower clock, and on the back the program machine. Below this panel are the trunk-line terminals. The various voltmeters, ammeters, cycle counters, and ampere-hour meters are arranged along the top and sides.

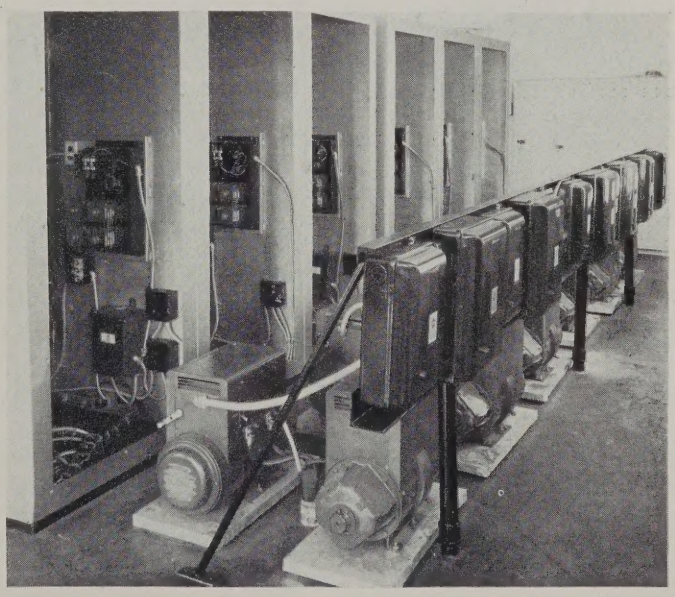

FIGURE 2.—*Motor generators, line starters, and interior of control cabinets for cycling units*

The motor-generators and line starters provide power for the six cycling units installed in the new Cycle-testing Laboratory at the National Bureau of Standards. Two machines are operated in parallel for each cycling unit when charging at constant potential. In the background are the control cabinets (back view), with the rectifiers for operating the switching devices. Transformers which supply the rectifiers are located in alternate cabinets.

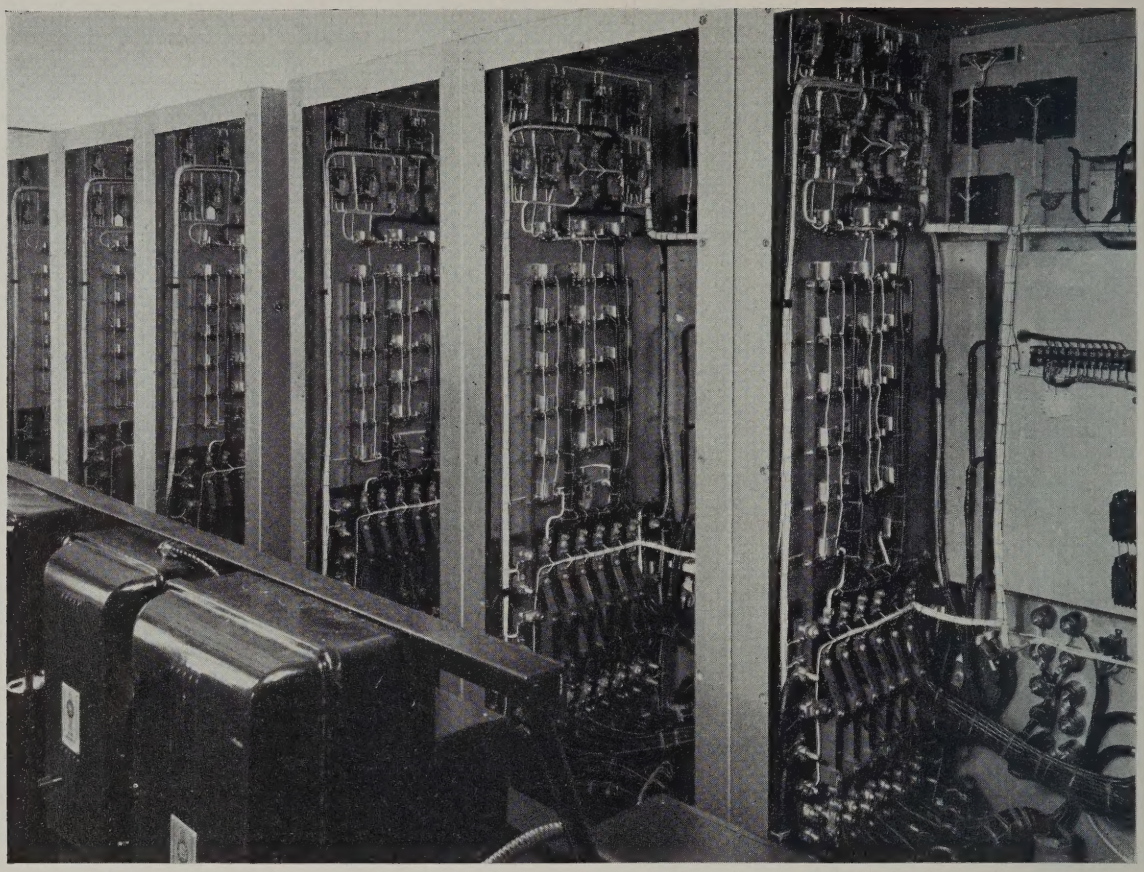

FIGURE 3.—*Control cabinets (back view) in the Cycle-testing Laboratory*

Inside each cabinet the sequence relays are mounted in two horizontal rows near the top, the contactors in the middle, and the shunts in two horizontal rows near the bottom of the wall.

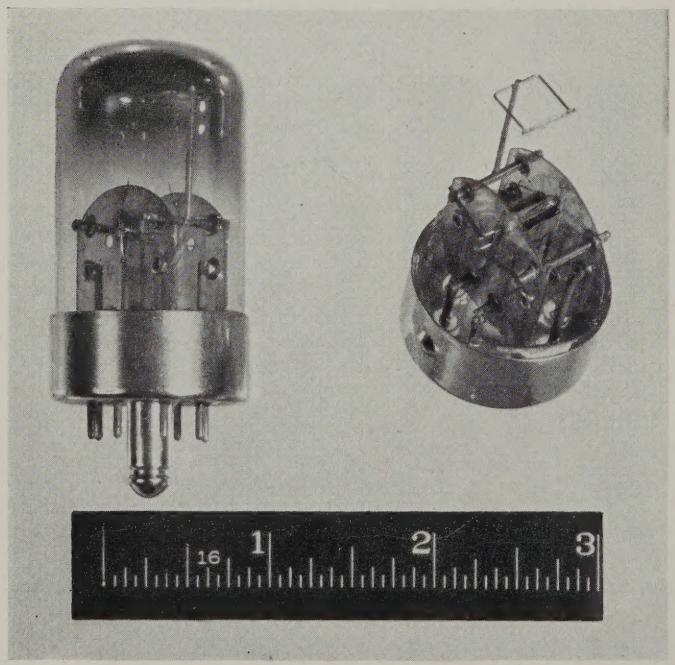

FIGURE 4.—*Vacuum-tube acceleration pick-up as developed at the National Bureau of Standards*

The vacuum-tube acceleration pick-up takes advantage of the effect of acceleration on the relative position of the electrodes in the tube. The tube contains a fixed, indirectly heated cathode with two plates, one on either side (right). The plates are elastically mounted to deflect in response to acceleration normal to the plane of the plates. Deflection of the plates causes a change in plate current proportional to the acceleration and such changes in current are recorded on a standard oscillograph.

plates. Deflection of the plates causes a change in plate current proportional to the acceleration and such changes in current are recorded on a standard oscillograph.

The elastic mounting of the plates was designed to give a fundamental frequency of about 800 cycles per second, in order to make the tube capable of recording accelerations with frequencies up to 200 cycles per second. Tests conducted at the Bureau on the latest type tubes (of which 95 have been built) have proven them to have the desired natural frequency with an output proportional to acceleration normal to the plates. The output for an acceleration of the order of 10 times gravity was of sufficient magnitude to record directly on a standard oscillograph without requiring an auxiliary amplifier.

The fundamental frequency of the plate structure for bending normal to the plate was computed by treating the structure as an elastic system with a concentrated mass at the center of gravity of the plates and distributed masses in the supporting wires, which are subject to flexure and torsion by the vibration of the plate normal to its plane. The diameters and lengths of the wires were computed to give a fundamental frequency in this mode in the range of 750 cycles per second. The natural frequencies of vibration in other modes were estimated to be much higher.

The fundamental frequency was determined experimentally by connecting the pick-up into a Wheatstone bridge with a cathode ray oscilloscope, tapping the pick-up with a pencil or finger, and matching the output on the oscilloscope by the output of known frequency for an audio oscillator.

The high output and high frequency of the vacuum tube make it possible to record rapidly varying accelerations without an amplifier, a desirable feature in flight tests of small airplanes where space and weight are at a premium. It also simplifies tests in the laboratory when amplifying channels are not readily available. The high capacity of the pick-up is advantageous in recording accelerations over a wide range and in preventing damage from sudden high accelerations. The linearity of the pick-up permits the filtering out of high frequency response and produces a record proportional to acceleration.

The development of the vacuum-tube acceleration pick-up was begun in 1941 for the Navy's Bureau of Aeronautics and was carried on with the cooperation of Sylvania Electric Products, Inc. In addition to experiments for the Army and Navy, the tubes are being tested under various service conditions by several flight laboratories to determine the full scope of their usefulness. In the meantime, they have already proven successful at the Bureau for measuring accelerations of a model airplane during drop tests.

Foreign Scientific and Engineering Relations

With the end of the war relations with scientific laboratories in other countries were renewed. During the summer of 1946, 12 members of the Bureau staff visited other nations; 18 Bureau engineers were (and still are) located at various stations in the Pacific; and another engineer was recalled by the Army to aid in the organization of a Standards Bureau in Korea.

In the 6 months from May 1 to November 1, 176 representatives of 35 countries visited the Bureau. Included among these visitors were 10 directors of research institutions whose programs are as broad as that of this Bureau and 9 directors of specialized research institutions, as well as research engineers, university professors, government officials, industrialists, and guest laboratory workers.

International conferences and scientific meetings were resumed. Dr. E. C. Crittenden, Associate Director, has just returned from Paris where he attended a meeting of the International Committee on Weights and Measures, the first since the war. Various matters relating to electrical, photometric, and other standards were considered and plans were made for the first postwar meeting of the International Conference on Weights and Measures.

Dr. H. L. Dryden, Associate Director, recently visited the leading European aeronautical laboratories and attended both the International Technical Congress and the International Congress for Applied Mechanics. Dr. Dryden was elected one of four representatives from the United States on the international committee of the latter. In England, Dr. Dryden also conferred with the Director of Building Research and the Director of the National Physical Laboratory on problems of mutual interest.

Dr. Walter Ramberg, chief of the Engineering Mechanics Section, visited the structures laboratories at the Royal Aircraft Establishment, National Physical Laboratory, and General Electric Laboratory in England; the laboratories of the Technical University of Delft, the National Luchtvaartlaboratorium in Amsterdam, and the Philips Natuurkundig Laboratorium, in Eindhoven; the laboratory of Professor Homes in Mons, Belgium; the Laboratorie des Travaux Publiques in Paris; the E. Material-pruefüngs and Verschsanstalt, Zürich; and the laboratories of A. W. Huggenberger in Zürich.

W. D. Appel, chief of the Bureau's Textiles Section and head of the Textiles Unit, Technical Industrial Intelligence Division, Office of Scientific Services, spent 8 weeks in Germany and 4 weeks visiting laboratories concerned with textiles and high polymer chemistry in Switzerland, Sweden, the Netherlands, and England. He obtained German scientific and technical wartime publications needed by the Bureau Library and brought back first-hand knowledge of textile testing methods and research abroad. The heads or representatives of textile research institutions jointly supported by industry and government in Sweden, Switzerland, the Netherlands, and England have visited the Bureau since his return.

D. R. Miller, Bruce L. Wilson, and L. B. Tuckerman

spent several days in Ottawa, Canada, discussing with representatives of the National Research Council of Canada, the Canadian Standards Association, and United States manufacturers, details of the United States' participation in a program of research on screw threads. An outgrowth of the efforts toward unification of screw threads in the three Nations, this research is a cooperative effort between the National Physical Laboratory in England, the National Research Council of Canada, and the National Bureau of Standards.

Dr. William Blum, chief of the Chemistry Division's Electrochemistry (Electroplating) Section, attended a conference of electrochemists at Toronto in October, at which he summarized the military applications of electroplating in World War II and participated in discussions of this and other problems. At the same conference, Dr. G. W. Vinal, chief of the Electrochemistry Section (Electricity Division), presided at a symposium on batteries, in which the Bureau's work on new primary batteries was explained. R. S. Dill, chief of the Heat Transfer Section, participated in conferences at Montreal on heating, air conditioning, and related subjects.

Dr. J. H. Dellinger, chief of the Central Radio Propagation Laboratory, served as a member of the United States delegation to a Telecommunications Conference in Moscow which took place September 28 to October 21. The Conference, a meeting of the five powers (USSR, Great Britain, France, China, United States) to consider international radio, telegraph, and telephone regulations, laid the groundwork for a world telecommunications conference of all nations to be held in the United States next year. The work of the Central Radio Propagation Laboratory on propagation and on standard frequency dissemination constitutes basic services very useful to such conferences and to the nations in administering the international regulations.

Dr. F. G. Brickwedde attended an international conference on low temperature physics and on physics of fundamental particles of atomic nuclei, at the University of Cambridge in July, and visited the low temperature laboratories at the Universities of Cambridge, Oxford, and Leiden (Holland). Dr. Brickwedde brought back important information for the Bureau's program in the low temperature field. At the National Physical Laboratory in England, Dr. Brickwedde discussed problems relating to the International Temperature Scale, which in the United States is maintained by the Bureau.

The Bureau scientists report that European science is recovering rapidly from the war; that national policies for the encouragement of science are being widely discussed, and that military restrictions on interchange of purely scientific data are being removed. There seems to be a sincere desire to promote international goodwill on the part of scientists, and there is a great desire both to learn of the progress of science in other countries and to demonstrate as a matter of national pride accomplishments in science made during the war.

Lecture Series on High Polymers

A series of lectures dealing with the chemistry and physics of high polymers will be given this season at the Bureau by the Nation's leading scientists in this field. High polymers is a new science concerned with the long-chain organic molecules of such substances as natural and synthetic rubbers. plastics, textiles, paper, and leather. The program, arranged by Dr. Robert Simha of the Division of Organic and Fibrous Materials, consists of 12 lectures:

November 22: "Theories of Fractional Precipitation of High Polymers as Applied to Cellulose Esters," D. R. Morey, Eastman Kodak Co.

December 13: "Visco-Elastic Properties of Polymer Solutions," J. D. Ferry, University of Wisconsin.

January 22: "On Quantum Mechanisms of a Macroscopic Scale," F. W. London, Duke University.

January 30: "Applications of Magnetochemistry to Polymers and Polymerization," P. W. Selwood, Northwestern University.

February 27: "Physical Chemistry of Collagen," J. H. Highberger, General Dyestuff Corporation.

March 6: "Solution Properties of Cellulose Derivatives—Correlation with Physical Properties," H. M. Spurlin, Hercules Powder Co.

March 28: "Effects of Low Temperature on High Elasticity of Rubbers," S. D. Gehman, The Goodyear Tire & Rubber Co.

April 24: "Elasticity and Plasticity of High Polymers," H. Leaderman, The Firestone Tire & Rubber Co.

May 8: "Electrical Properties of Polymers," R. M. Fuoss, Yale University.

May 29: "Polar Coordination in Solid Polymers," W. O. Baker, Bell Telephone Laboratories.

June 5: "Optical Investigations on Polymers," W. Heller, Wayne University.

June 12: "Discoloration of Polymers," R. F. Boyer, The Dow Chemical Co.

Dr. Hugh L. Dryden Awarded Medal of Freedom

America's second highest decoration for civilians, the Medal of Freedom, has been awarded to Dr. Hugh L. Dryden, Associate Director of the Bureau and chief of the Mechanics and Sound Division, according to a recent War Department announcement. As a member of the AAF Scientific Advisory Group, Dr. Dryden obtained invaluable information on guided missile projects planned and carried out by the enemy and on the aeronautical research by German scientists on supersonic missiles (faster than the speed of sound). He is now serving as chairman of the Guided Missile and Pilotless Aircraft Panel of the Scientific Advisory Board to the Commanding General, Army Air Forces.

Dr. Dryden has directed the Bureau's research and development program on guided missiles, in connection with both the BAT, the only guided missile successfully used in combat, and the "Kingfisher Project" on advance forms of guided missiles. A member of the Bureau staff since 1918, he has been engaged in re-

search on aerodynamics, properties of airfoils at high speeds, wind-tunnel investigations, wind pressure on structures, and turbulence, and has contributed extensively to scientific journals in these fields.

Dr. L. L. Marton Joins Staff of Electronics Section

Dr. Ladislaus L. Marton has recently joined the staff of the Electronics Section as principal physicist, where he will initiate a program of research on the basic theory, methods, and applications of electron and ion beam devices. The work will cover those phases of the program of the Electronics Section which involve the theory and application of scientific devices which fundamentally involve the directed flow of electron and ion beams. Dr. Marton will also teach a course in electron optics in the Bureau's Graduate School.

Dr. Marton is internationally known for his work in electron optics, particularly in connection with the development and perfection of the electron microscope, which has proven a powerful research tool to science in the study of the structure of molecules, the structure of bacteria, the photograph of viruses and other minute objects. He began work on the electron microscope at the University of Brussels in 1932. More recently Dr. Marton has been associate professor of physics and head of the Division of Electron Optics at Stanford University. Dr. Marton has contributed extensively to scientific journals in the field of infrared, photoelectricity, physical photometry, and radiography.

Dr. Churchill Eisenhart Named Principal Mathematician

The appointment of Dr. Churchill Eisenhart as Principal Mathematician directly in charge of the statistical work of the National Bureau of Standards, was announced recently by the Director. Dr. Eisenhart is on leave of absence during the academic year 1946–47 from the University of Wisconsin, where he is associate professor of mathematics.

An authority in mathematical statistics, Dr. Eisenhart has contributed extensively through his research to the field, particularly in developing mathematical statistics as a research tool in science and engineering.

Dr. Eisenhart has been serving as statistician at the Wisconsin Agricultural Experiment Station and has been a member of the University of Wisconsin faculty continuously since 1937. During the War, Dr. Eisenhart was engaged in war research for the Special Devices Section of the Navy's Bureau of Aeronautics and for the Applied Mathematics Panel of the National Defense Research Committee. In recognition of his war work, he received the Ordnance Development Award in 1946 from the Bureau of Ordnance, U. S. Navy.

New and Revised Publications Issued During November 1946

Journal of Research [1]

Journal of Research of the National Bureau of Standards, volume 37, number 5, November 1946 (RP1747 to RP1751, inclusive). Price 30 cents. Annual subscription, 12 issues, $3.50.

Title page, corrections, and contents for volume 36, Journal of Research, January to June 1946 (RP1688 to RP1722, inclusive). Price 5 cents.

Research Papers [1]

RP1730. Viscosity and the extraordinary heat effects in glass. 10 cents.

RP1731. An arrangement with small solid angle for measurement of beta rays. 5 cents.

RP1733. A study of the damaging effect of fatigue stressing on SAE X-4130 steel. 10 cents.

RP1734. Purification, purity, and freezing points of 31 hydrocarbons of the API-NBS series. 10 cents.

RP1735. Absorption measurements for broad beams of 1- and 2-million volt X-rays. 10 cents.

RP1736. Effect of reaction between mercury and oxygen upon polarographic waves of certain metals at small concentrations. 10 cents.

Basic Radio Propagation Predictions [1]

CRPL–D27. Basic radio propagation predictions for February 1947 three months in advance. Issued November 1946. Price 15 cents. Annual subscription, 12 issues, $1.50.

Commercial Standard [1]

CS136–46. Blankets for hospitals (wool, and wool and cotton). Price 5 cents.

Simplified Practice Recommendations [1]

R195–46. Dental excavating burs. (Supersedes R195–42). Price 5 cents.

R208–46. Fluid milk cans. (Supersedes R208–45). Price 5 cents.

Technical News Bulletin [1]

Technical News Bulletin 355, November 1946. Price 5 cents. Annual subscription, 12 issues, 50 cents.

Mimeographed Material

Weights and Measures News Letter No. 44, issued by the National Bureau of Standards in cooperation with the National Conference of Weights and Measures (September-October 1946). (National Bureau of Standards, Washington 25, D. C.). Available without charge from the Bureau.

Letter Circulars

(Letter Circulars are prepared to answer specific inquiries addressed to the National Bureau of Standards, and are sent only on request to persons having a definite need for the information. The Bureau cannot undertake to supply lists or complete sets of Letter Circulars or send copies automatically as issued)

LC835. Lime: technical publications by members of the staff of the National Bureau of Standards. (Supersedes LC144).

LC836. List of commercial standards. Revised to October 1, 1946. (Supersedes LC833).

LC837. Painting interior walls and trim. (Supersedes LC304).

[1] Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington 25, D. C. Subscription to Technical News Bulletin, 50 cents a year; Journal of Research, $3.50 a year (to addresses in the United States and its possessions and to countries extending the franking privilege); other countries, 70 cents and $4.50, respectively. The price of other publications is indicated in the lists.

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